

Biology of *Halyomorpha halys*, The Brown Marmorated Sink Bug (BMSB)  
Final Report - USDA APHIS CPHST 2004 (one year project)

Gary Bernon

## **Introduction**

This report will provide a summary of a one-year project on *Halyomorpha halys*, the Brown Marmorated Stink Bug (BMSB). The primary goal was to observe the field biology and evaluate the risk potential of this new invasive species. A second objective was to document host plants and conduct a delimiting survey. To the extent possible, reference is made to the impact the BMSB will have on existing integrated pest management strategies (IPM) for key risk crops (see separate reports on peach, pear, soybean, and paulownia tree). These reports will be submitted as separate documents, as requested. Also, see attached CPHST Work Plans on BMSB for fiscal year 2003, and fiscal year 2004).

## **History of BMSB in North America**

*Halyomorpha halys* (Heteroptera: Pentatomidae), was reported from Allentown, PA in early October, 2001. The positive identification was made by E. Richard Hoebeke, Curator at the Cornell University Insect Collection (Hoebeke and Carter, 2003). This is the first record of an established breeding population of this species in North America. However, Karen Bernhard, an entomologist with the Lehigh County Extension (Allentown, PA), had received complaints about this insect for several years prior to this documented identification (Bernhard, pers. comm.). The delay was due to an earlier misidentification, as there are several similar indigenous species of stink bugs. The BMSB overwinters as an adult, and will often enter homes and other buildings in the fall when seeking sheltered sites. It was this behavior that caused residents of Allentown to continue expressing concern with the Lehigh County Extension. As a result, Karen Bernhard took the initiative to have specimens re-examined by another taxonomist, thus resulting in the correct identification.

## **Initiative by The Center for Plant Health Science and Technology (CPHST), USDA, APHIS, Plant Protection and Quarantine (PPQ)**

The Center for Plant Health Science and Technology (CPHST), was directed by the Deputy Administrator of PPQ, to evaluate the status of this new invasive species. Gary Bernon from the Pest Survey, Detection and Exclusion Laboratory, was appointed as Project Leader. Several preliminary site visits were made in August and September, 2002, while formal project authorization was pending. After interviewing residents in Allentown, it became apparent that the BMSB had been in Allentown at least since 1996, and possibly even earlier. These early reports could not be documented with voucher specimens and therefore could not be confirmed. The earliest reliable record at the Lehigh County Extension Center, albeit without a voucher specimen, was recorded by Karen Bernhard in 1996. The uncertain date of first introduction, and early confusion

with similar indigenous species, is typical for newly introduced invasive species. Although Karen Bernhard had done host plant surveys in 2002, there had been no effort to evaluate the pest status of BMSB in PA. The CPHST project was authorized on May 14, 2003, although plans for the 2003 field season were already in place. The project was terminated on February 13, 2004 (see Fiscal Year 2003 Work Plan: Biology of *Halyomorpha halys*, the Brown Marmorated Stink Bug).

### **Methods and Objectives of BMSB Project**

From the literature, the BMSB is known to be indigenous to China, Korea, Taiwan, and Japan. In all countries, the BMSB has been reported to be a polyphagous pest. Host plants include, but are not limited to, various fruit trees, vegetables, and row crops, including soybeans. The exact damage attributed to the BMSB is often not known because it is one of a complex of stink bug species that all do identical damage (see Hoebeke and Carter, 2003, for a review of literature in countries of origin).

After the identification, The New Pest Advisory Group (NPAG), part of CPHST, completed an initial review of the BMSB (NPAG Data on BMSB, October 26, 2001). The work plan for a CPHST project was drafted by Gary Bernon and submitted in early 2003, and approved in May, 2003. The submitted work plan had a budget of \$44,547 (as submitted), but approved in May at \$29,547 (laboratory work was eliminated).

### **Original Work Plan (with modifications as indicated)**

(1) Life History, Behavior and Ecology (Bionomics) - Field Study. Monitor field populations within the infested area, and determine the life cycle. This will include identifying host plants, number of generations per season, oviposition time and duration, and number of eggs/mass. Field observations will also determine mating behavior, any possible mortality factors, and observed behavioral patterns such as clustering and feeding.

In August, 2002, during preliminary visits, a site was identified for monitoring field populations. Permission was obtained from the owner. This 55 acre property is owned by the Rodale Organization, a publishing company. The property is officially called "The Rodale Working Tree Center" (RTC). The entire property was landscaped with many ornamental plantings and a number of previously identified host plants.

As part of the approved work plan, a part time technician was hired in Allentown to be the on-site technical support for monitoring. The project leader would visit the site as time permitted to assist with all field work. Karen Bernhard, who worked part time for the Lehigh County Extension, was hired by CPHST. The Lehigh County Extension Center was also used as a base of operations (informal agreement with Director).

(2) Life History, Behavior and Ecology (Bionomics) - Laboratory Study. Overwintering adults from a lab. colony will be reared under controlled environments (Percival Chambers). Preliminary rearing at Otis and Cornell has shown that the BMSB can be

reared on a variety of hosts and diapause can be broken. Data collected will include potential generations per season, duration of life stages, fecundity, mating and pre-mating behavior, pre-oviposition period, breaking and inducing diapause, and optimum rearing environment. A part time technician has been requested to maintain colony and assist with collecting data. If no support is available, a colony could still be maintained as in 2002; however any experiments would be minimal and at ambient conditions (in 2002 there were no experiments). This part of original work plan was not approved and support was canceled in May, 2003. Also resubmitted in 2004 when project was canceled).

(3) Host Specificity Tests - Field Study. I have arranged with Rodale to study host specificity of wild population of BMSB at their 333 acre Research Institute in Lehigh County. They grow apples and soybeans, which are two primary potential agricultural hosts for BMSB. Both crops would be monitored weekly. A specific sampling regime will be used, a beating net will be used for apples and a sweep net for soybeans. A random sample will be taken for 10 minutes each week. Specimens will be retained. The objective is to evaluate the primary risk plants in the field. Damage (if any) on soybeans and apples will be evaluated at harvest. The research manager at the Rodale Institute, Dr. Paul Hepperly, is experienced at grading stink bug damage to soybeans and will provide support. A survey to locate additional natural host plants will also be conducted by a random survey on residential properties and in old field habitats. The Rodale Experimental Tree Farm can also be used to monitor additional tree species to identify new host plants.

(4) Nuisance Pest Status and Management Strategies - Field Studies. Although not a priority for APHIS, the only concern to date in Allentown is the nuisance status of BMSB. This is also a major problem in Japan. The adults will omit a noxious scent if disturbed or swept up in a vacuum. There are existing control strategies in Japan, and at the very least these will be reviewed and summarized, then made available to the public perhaps as a fact sheet (via LPA within APHIS). This would not necessarily be a priority for APHIS, however in Allentown it is the only priority and therefore will not be ignored. The opportunity to collaborate with the leading pest control company in the area may be explored (see stakeholders), to at least document urban pest control protocols and compare to any existing strategies in Japan. They have also offered to provide records to help with delimiting survey work. (I have learned that home-owners are being advised by one private sector garden supply company to spray Sevin in their homes as it is registered for use on stink bugs; this adds further support to not ignoring the nuisance aspect of this pest.)

(5) Biological Control and Other Natural Mortality Factors - Lab Studies. Naturally occurring mortality factors will be evaluated by collecting adults and late instar nymphs to rear for emergence of parasitoids (animals may be used from other studies). For example, spiders have already been observed as a mortality factor, and the literature indicates that at least one species of tachinid will parasitize adult stink bugs and later emerge from the over-wintering adult. Host switching can be evaluated by rearing field collected adults. I have observed an exit hole in a dead over-wintering adult that was

probably caused by a tachinid. All work would need to be done in the quarantine lab; I estimate 25 % of the lab space would be needed, including the two environmental chambers. The exact number of replications would be a function of this space. Another option would be to work within the infested area, and avoid the need for using a quarantine lab. There are several universities in this area (i.e. Lehigh University), these options are being pursued. Any field observations of mortality or parasitoids will be noted. This part of original work plan was not approved and support was canceled in May, 2003; also resubmitted in 2004, project canceled; however limited field observations of natural mortality factors were made).

(6) Provide Scientific Support to APHIS-ER Delimiting Survey - Field Study. Although some extension survey work was done during the active season of 2002, this was limited to the Allentown area. CPHST will assist the Eastern Region in standardizing a survey to delimit distribution and will help incorporate collection of related data, such as host specificity. PPQ Officers will need to be trained to distinguish the BMSB from several other indigenous species (field identification of BMSB). During the over-wintering flight of adults, the lead scientist and field technician will assist with delimiting surveys as adults can be easily located. A fact sheet to clarify this problem will be completed.

Note: Two additional monitoring sites were added at the start of the field season as laboratory work was not supported: a backyard fruit grower (Mr. Don Dries Property, and a 130 farm at the edge of the infestation, the Mr. Mark Lichtenwainer Farm).

## **Results**

Only one generation was observed in Allentown (univoltine). We did monitor the Rodale Tree Farm (RTF) site at least once a week from April 14, 2003 until October 6, 2003. Although adults were observed leaving overwintering sites (homes) at the end of April near the RTF site, adults were not observed on host plants at the monitoring site until late May. However, if eggs had been oviposited, we would have observed nymphs, if not the egg masses. Therefore, there is a long mating and pre-oviposition period.

*Paulownia tomentosa* – Paulownia tree, or Princess tree.

This host plant had previously been observed to support dense populations of BMSB at this site in 2002. Therefore, this host was monitored on at least a weekly basis. There were two separate groves of this tree with about 10 trees each. Both patches proved to be heavily infested. We made observations on 40 days. Trees did not have bud break until the end of May. The first adult was observed on June 24. The first egg mass was collected on July 3. Peak oviposition was throughout July. During July a series of 47 egg masses were collected from Paulownia trees (Figure 1). The egg mass size was very consistent, with 72% of the masses having 28 eggs. The same pattern was confirmed in the laboratory colony. The last egg mass was collected on August 20.

First instar nymphs clustered on the egg mass for several days before disbursing. Although egg masses were difficult to see before they eclosed, the clustering first instar

nymphs were easier to observe. Egg masses were always laid on the underside of leaves, not near the leaf margin. Occasionally first instar nymphs stayed on the egg mass until molting to second instars (approximately one week or less). By the end of July, all five nymphal instars were found together. Although nymphs were solitary feeders, occasionally they would form aggregates and cluster between overlapping leaves or leaf folds. Occasionally nymphs would aggregate with other Heteropterans, including a coreid and a stink bug (*Acrosternum hilare*).

*Acrosternum hilare* is a pest on soybeans, corn, tree fruits and cotton. The behavior of this indigenous species has been thoroughly studied (McPherson and McPherson 2000). The BMSB appeared to have behavioral traits similar to *A. hilare*, and therefore *A. hilare* may be a valuable model to predict the impact of BMSB when it expands its range. For example, *H. hilare* and the BMSB are univoltine in PA, but *H. hilare* is bivoltine in the southern U.S. Also, *H. hilare* is known to use several different host plants at different times during its annual life cycle in the north; the same behavior appeared to apply to BMSB but more than one season would be needed to confirm this.

F<sub>1</sub> adults were first observed in mid August. Although we were not able to distinguish overwintered adults from new adults, we did observe the fifth instar nymphs in early August and can therefore be certain that new adults would appear within approximately a week. Mating was observed only in the spring after diapause and not in the fall.

Adults and nymphs feed on the paulownia leaves. Feeding was most common on the upper leaf surface, with nymphs often aggregated in leaf folds or between overlapping leaves. As the season progressed, leaf damage increased and by mid August every leaf on the tree was heavily damaged. New adults remained on the host plant to feed. If disturbed, both nymphs and adults would drop off the leaf or move rapidly out of sight. On warm days adults would take flight if disturbed, but usually for only short distances.

Two egg parasitoids were reared from BMSB egg masses collected on *Paulownia*. These were identified by Walker Jones (pers. comm., Jones, 1988):

*Telenomus podisi* Ashmead (Hymenoptera: Scelionidae): According to Jones (pers. comm.), “*T. podisi* is the most common pentatomid egg parasitoid in North America, with the greatest host range; so I’m not surprised it attacked *Halyomorpha halys*.”

*Anastatus* spp. (Hymenoptera: Eupelmidae): According to Jones (pers. comm.), “*Anastatus* spp. attack almost any kind of insect egg and I think some are either hyperparasitic or facultatively so. The genus occurs worldwide and I’ve never been able to get a species name for ones I’ve collected from stink bug, coreids and tettigoniid eggs. I’ve never found it as a dominating species.”

*T. podisi* is well documented as a factor in the biological control of pest stink bug species, including *Nezara viridula*, *Acrosternum hilare*, and *Piezodorus guildinii* (Jones, 1988). This is a host new record for North America.

Although *Anastatus* spp. have been used in biological control and even reared for augmentative releases, the role of this species with reference to BMSB is unknown. Both species will need to be studied as parasitoids of BMSB, especially if it invades agroecosystems (Jones, 1988).

At least one species of tachinid fly was often seen stalking BMSB on *Paulownia*. A dead adult BMSB with an apparent tachinid exit hole was collected. Tachinids also flew into pheromone-baited traps tested to attract the BMSB (identification pending). *Trichopoda pennipes* is a cosmopolitan parasitoid of stink bugs and would be likely to attack the BMSB (Dietrick and van den Bosch 1957). Other observed predators including a lacewing larva, ants, and spiders. On five occasions, both in the spring and fall, adults were observed in spider webs on the sides of homes.

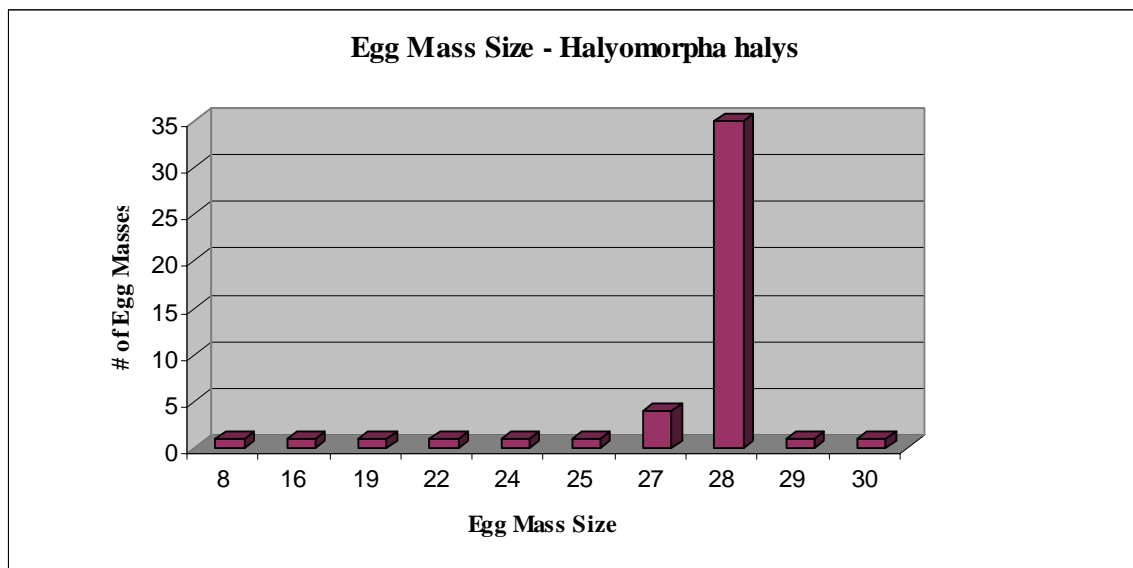


Figure 1. Egg mass size of *Halyomorpha halys* feeding on *Paulownia tomentosa*.

### Host Plant Survey

The complete list of host plants of BMSB observed in 2002 and 2003 is summarized in Table 1. A preliminary host plant survey had documented plants in the immediate Allentown area (Bernhard, pers. comm.). Random host plant surveys in 2003 were also done in the five counties with positive reports of the BMSB, and the combined list is presented here.

**Table 1. Host Plants of *Halyomorpha halys* – Allentown, PA**

	<b>Plant name</b>	<b>Scientific name</b>	<b>Frequency</b>
1	Butterfly Bush	<i>Buddleia davidii</i>	Abundant
2	Catalpa	<i>Catalpa</i>	Abundant
3	Crabapple	<i>Malus</i>	Abundant
4	Paulownia (Princess Tree)	<i>Paulownia tomentosa</i>	Abundant
5	Rugosa Rose	<i>Rosa rugosa</i>	Abundant
6	Siberian Pea Shrub	<i>Caragana arborescens</i>	Abundant
7	Apricot	<i>Prunus</i>	Abundant
8	Pole Bean	<i>Phaseolus</i>	Common
9	Bush Bean	<i>Phaseolus</i>	Common
10	Cherry, Black	<i>Prunus</i>	Common
11	Firethorn	<i>Pyracantha</i>	Common
12	Glossy Abelia	<i>Abelia x grandiflora</i>	Common
13	Honeysuckle	<i>Lonicera</i>	Common
14	Lilac	<i>Syringa</i>	Common
15	Maple, Norway	<i>Acer platanoides</i>	Common
16	Peach	<i>Prunus</i>	Common
17	Pear, European	<i>Pyrus</i>	Common
18	Pear, Asian	<i>Pyrus</i>	Common
19	Plum, Ornamental	<i>Prunus</i>	Common
20	Raspberry	<i>Rubus</i>	Common
21	Serviceberry	<i>Amelanchier</i>	Common
22	Apple	<i>Malus</i>	Occasional
23	Dogwood, Gray	<i>Cornus racemosa</i>	Occasional
24	Dogwood, Redosier	<i>Cornus sericea</i>	Occasional
25	Filbert, Turkish	<i>Corylus colurna</i>	Occasional
26	Grape (Cultivated)	<i>Vitis</i>	Occasional
27	Grape (Wild)	<i>Vitis</i>	Occasional
28	Hackberry	<i>Celtis occidentalis</i>	Occasional
29	Holly	<i>Ilex</i>	Occasional
30	Holly, Winterberry	<i>Ilex verticillata</i>	Occasional
31	Persimmon	<i>Diospyros</i>	Occasional
32	Plum	<i>Prunus</i>	Occasional
33	Privet	<i>Ligustrum</i>	Occasional
34	Redbud	<i>Cercis canadensis</i>	Occasional
35	Viburnum, Blackhaw	<i>Viburnum prunifolium</i>	Occasional

36	Cranberry busy	<i>Viburnum</i>	Occasional
37	Viburnum, Tea	<i>Viburnum setigerum</i>	Occasional
38	Willow, Pussy	<i>Salix</i>	Occasional
39	Ash	<i>Fraxinus</i>	Rare
40	Asparagus	<i>Asparagus</i>	Rare
41	Birch	<i>Betula</i>	Rare
42	Bittersweet	<i>Celastrus</i>	Rare
43	Buckthorn	<i>Rhamnus</i>	Rare
44	Burcucumber	<i>Sicyos angulatus</i>	Rare
45	Burdock	<i>Arctium minus</i>	Rare
46	Cherry, Sour	<i>Prunus</i>	Rare
47	Cleome	<i>Cleome</i>	Rare
48	Comfrey	<i>Symphytum</i>	Rare
49	Cucumber	<i>Cucumis sativus</i>	Rare
50	Elder	<i>Sambucus</i>	Rare
51	Euonymus	<i>Euonymus</i>	Rare
52	Euonymus, Winged	<i>Euonymus alatus</i>	Rare
53	Goldenrain Tree	<i>Koelreuteria</i>	Rare
54	Hawthorn	<i>Crataegus</i>	Rare
55	Holly, American	<i>Ilex opaca</i>	Rare
56	Jetbead	<i>Rhodotypos scandens</i>	Rare
57	Linden	<i>Tilia Americana</i>	Rare
58	Maple, Hedge	<i>Acer campestre</i>	Rare
59	Maple, Japanese	<i>Acer palmatum</i>	Rare
60	Maple, Red	<i>Acer rubrum</i>	Rare
61	Mountainash	<i>Sorbus</i>	Rare
62	Mulberry	<i>Morus</i>	Rare
63	Nightshade	<i>Solanum</i>	Rare
64	Pecan	<i>Carya</i>	Rare
65	Pepper, green	<i>Capsicum</i>	Rare
66	Soybean	<i>Glycine max</i>	Rare
67	Spiraea	<i>Spiraea</i>	Rare
68	Star Magnolia	<i>Magnolia stellata</i>	Rare
69	Sumac	<i>Rhus</i>	Rare
70	Sunflower	<i>Helianthus</i>	Rare
71	Sycamore	<i>Platanus occidentalis</i>	Rare
72	Tomato	<i>Lycopersicon</i>	Rare
73	Walnut	<i>Juglans nigra</i>	Rare

### **Summary of monitoring at the Rodale Tree Farm (RTF).**

*P. tomentosa* at the RTF had the largest population and would be the best option for future studies of field biology within an infested area. The site is also organically maintained thus avoiding chemical contamination. At least eight host plants at the RTF had abundant (every site visit after first appearance) or common (at least every other site visit): butterfly bush, crabapple, rugosa rose, Siberian pea shrub, black cherry, Asian pear, and raspberry, and serviceberry (between mid June and early October). These populations were patchy and would be difficult to use for detailed studies. Although the 55 acre site is currently under landscaping renovation, it is in effect an arboretum open to the public and available for research; the owner's only requirement is that plants are not damaged.

### **Monitoring at Mr. Don Dries Property (Dries Site).**

The property is located within the infestation in Allentown, PA. The owner reported that his peach crop had been lost to stink bug damage in 2002. Unfortunately, it was too late to see and evaluate the damage (November, 2002). Arrangements were made to monitor his fruit trees in 2003. The property was visited 40 times between April 24 and October 6. All risk plants at the Dries site were sampled at each visit (including peach, pear, apricot, raspberry, string bean, plum, and a number of ornamentals).

We confirmed the reported peach damage in 2002. During April and May, no BMSB activity was noted at the Dries Site. In early June, the first overwintering adults were observed on the property. During June, adults in large numbers were collected emerging from a shed on the property. At the end of June, adults were observed in low numbers on fruit trees, a single egg mass was found on June 30 on an apple tree. Nymphs appeared, again in low numbers in July. Although observed on fruits, there was no observed damage. In August, the owner had moderate numbers that he collected from fruit trees during the previous week. In mid August, nymphs were observed feeding on fruits. The fruits were dripping, this was the first sign of damage. This damage was noted within four days of a combined Bonide/Imidan spray. As the damage progressed in August, arrangements were made with fruit tree entomologists from Penn. State and Rutgers University to visit the Dries site to observe the damage.

Dr. Peter Shearer, a tree fruit entomologist from Rutgers University, visited the site on August 19<sup>th</sup>. He has specialized in stink bug damage on fruit trees, his report follows:

---

Memo. From Dr. Peter Shearer, Rutgers University:

Rutgers Agricultural Research  
and Extension Center  
121 Northville Rd.  
Bridgeton, NJ 08302-5919

NEW JERSEY AGRICULTURAL EXPERIMENT STATION Phone: 856/455-3100

Fax: 856/455-3133

Web: [www.rce.rutgers.edu](http://www.rce.rutgers.edu)

Memo

TO: Gary Bernon, USDA, APHIS

FROM: Peter W. Shearer

DATE: Aug. 21, 2003

RE: *Halyomorpha halys*

This memo is in response to my Aug. 19, 2003 visit to some of your *Halyomorpha halys* study sites in Allentown, PA. I have been working with stinkbugs off and on my entire professional career and I have never seen such stink bug abundance and damage as I saw in Allentown, PA. *H. halys* was very prevalent and easy to find as was their damage. Putting the nuisance aspect (overwintering in homes) aside, I expect that *H. halys* will become a serious problem to agriculture. I am surprised that more effort has not been focused on this insect. Once *H. halys* becomes established in commercial production areas, I expect that growers will spraying a lot of insecticides to control this insect thus increasing production costs and impact to the environment.

As a result of this visit, I have indicated to my administration that I need to work with this insect. Hopefully we can form a collaborative project and include Dr. Greg Krawczyk, Penn State U. Tree Fruit Entomologist. In addition to your basic biology and survey work, we need to know how to manage this pest before it causes hardships to local agriculture. I have contacted our NJ Department of Agriculture about the serious threat this insect poses to NJ agriculture. It is possible that they may be able to provide additional expertise, possibly with developing a biological control program.

Again, I don't think that senior administrators realize just how serious this insect is. More resources are needed to study this insect and devise ways to manage it and minimize its spread. I look forward to possibly working with you on this insect problem.

---

Although the trees were sprayed with an all purpose fruit tree spray (Bonide), and even supplemented with Imidan (both sprayed every ten days from mid April until the end of August), the peach crop was totally lost (see Figure 2). BMSB was observed feeding on

all other tree fruits on the property, but damage was only observed on Asian pear and apple. However, these fruits were still marketable with some damage. At the end of the season (late August to early October), late instar nymphs and adults were found feeding on any ornamental on the property that had berries (see Table 1). Apparently late in the season the BMSB will actively switch hosts, both as nymphs and adults. This behavior has been reported with other species, and will need to be studied in the future.



Figure 2. Newly emerged *Halyomorpha halys* actively feeding on a peach at the Don Dries Property on September 11, 2003, Allentown, PA.

Starting at the end of August, the Rutgers team used the Dries Site and the RTF site to do some preliminary testing of pheromone-baited traps. Results are pending, but the traps did attract adult BMSB until early November. The pheromone from BMSB is currently being extracted by Dr. J. Aldrich, USDA ARS; traps will be tested in 2004.

### **Results from the Lichtenwainer Farm Site.**

The 130 acre farm is located in southern Lehigh County, PA, located within the BMSB infestation. The site has been surrounded by housing subdivisions and is therefore in direct contact with adults that overwintered in homes. The previous fall the owner

reported finding several adults in his house which is on the property (these were confirmed). One main crop was soybeans which were the main target species at the site. Asian pears, apples, apricots, vegetable crops, and weeds were also monitored. The farm was visited weekly from April 18 until September 29, 2003. A total of 64 observations were made (each potential host plant species per visit). The first adult was observed was collected on June 23 (found dead in the house). Starting on June 30, occasional adults were found on the Asian pears. Several adults were also collected in July on grapes, apricots, and on several weeds (see Table 1). Starting in early August, adults and nymphs were collected in low numbers starting in on pecans and raspberry. Only at the end of September, several adults and nymphs were collected on soybeans (three visits). Specimens were limited to the edge of the field and although observed feeding on pods, there was no observed damage. At least one more season of monitoring would be needed to confirm any trend, but soybeans were confirmed as a host (no damage observed).

### **Results from the Rodale Institute Experimental Farm, Kutztown, PA.**

The 333 acre farm is an organic experimental farm in Berks County to the east of Lehigh County (Allentown). Organically grown apples and soybeans were monitored once or twice a month. The site was located outside the infestation, although there were a few reports of overwintering adults from Kutztown, which is actually several miles to the east of the farm. All records were negative, but this would be valuable if the site were monitored after the BMSB has established in that immediate area. All crops are grown organically, and any management strategies would therefore need to stress cultural and non-chemical IPM. For example, the apples were managed with Surround, a new organic clay product now widely used by organic growers.

### **Delimiting Survey Results.**

As time permitted, random surveys were done in counties abutting Lehigh County to delimit the distribution of the BMSB. Survey trips were combined with observations for new host plant records (see Table 1). The distribution of the BMSB was expanded to the east and west. To the west, specimens were found in Mertztown, and in Reading to the southwest (both are in Berks County, at least 25 miles from Allentown). Populations to the west become very patchy and no breeding populations were located.

To the east, adults were collected on several occasions in Stewartsville, NJ, expanding distribution across the Delaware River into NJ (Warren County). Stewartsville, NJ is 35 miles directly east of Allentown on a major highway (Interstate 78).

Rutgers University has also found individual adults in black light traps from several locations. One adult was confirmed from Little York, Warren County. In October, 2004, an apparent isolated population was found in Hagerstown, MD (Leskey, pers. comm.). In November and December a number of records were confirmed from counties in PA between Allentown and Harrisburg. It now appears the Hagerstown population may not be isolated but instead there may be patchy populations throughout central and southeastern PA. These reports are primarily from overwintering adults

found in homes. Rutgers University will be monitoring the BMSB in 2004 and provide detailed records. Work in PA will now be apparently limited to the Lehigh County Extension. The USDA ARS Appalachian Fruit Research Station will be delimiting the distribution of the population around Hagerstown, MD. In summary, it appears that the BMSB has just started to expand rapidly from the original infestation in Allentown, PA. As a result, it is likely to impact on commercial growers for the first time, possibly as soon as 2004.

To assist with delimiting survey work and provide public awareness, an effort was made to provide information to the public. A number of fact sheets, display presentations from professional meetings, and other documents are now available on the internet, most with direct input from this project:

<http://www.ento.psu.edu/extension/factsheets/yellowbrownstinkbug.htm>

<http://unisci.com/stories/20014/1011014.htm>

<http://www.news.cornell.edu/Chronicles/11.1.01/stinkbugs.html>

<http://www.rce.rutgers.edu/pubs/pdfs/fs002.pdf>

<http://www.invasive.org/browse/subject.cfm?sub=9328>

[http://mrec.ifas.ufl.edu/lso/pestalrt/Stink bug/Brown Marmorated Stink Bug.doc](http://mrec.ifas.ufl.edu/lso/pestalrt/Stink%20bug/Brown%20Marmorated%20Stink%20Bug.doc)

<http://www.dcnr.state.pa.us/forestry/leaflets/stinkbug.htm>

<http://www.dcnr.state.pa.us/forestry/leaflets/stinkbug.htm>

<http://ifplantscouldtalk.rutgers.edu/factsheets/factsheet.asp?fsnumber=FS002>

[http://mrec.ifas.ufl.edu/lso/pestalrt/Stink% 20bug/Peter% 20Shearer.pdf](http://mrec.ifas.ufl.edu/lso/pestalrt/Stink%20bug/Peter%20Shearer.pdf)

<http://www.cphst.org/docs/Annapolis03.pdf>

<http://www.nepmc.org/cwg/fruit/Prioritiesnov2003.html>

<http://www.google.com/search?q=Halyomorpha+halys&hl=en&lr=&ie=UTF-8&oe=UTF-8&start=20&sa=N>

## **Supplemental Research not funded by CPHST.**

Three cooperative arrangements provided the following research and results:

1. Paulownia Witches' Broom Disease - This phytoplasma disease is vectored by the BMSB in Asia and as a result importation of living *Paulownia tomentosa* is quarantined (Jin et al. 1981). BMSB in theory could also vector "yellows diseases", also phytoplasma diseases that can be disastrous to fruit tree crops and ornamentals (Welliver 1999). LeAnn Bearland in the Department of Viticulture at Virginia Tech. has tested BMSB for the presence of phytoplasma:

"Because *Halyomorpha halys* has been implicated in the transmission of Witches' Broom Phytoplasma to Paulownia trees in China (Jin et al. 1981), it is of particular concern to orchardists, foresters, nursery owners and homeowners here in North America. We have begun testing collected specimens to determine their vector competence and the risk of phytoplasma disease transmission to fruit, forest and landscape trees by this abundant and fast-spreading species. Five individual specimens were collected from four sites in Allentown, PA. DNA was extracted from each sample; Samples were tested for the presence of phytoplasma by nested PCR analysis with universal phytoplasma primers. None of the 5 insect samples were found to be infected or harboring phytoplasma. Testing of *H. halys* will continue in 2004 with special emphasis on insects collected in or near orchards, especially those with yellows-infected trees" (Bearland, pers. comm.).

2. Origin of PA population of BMSB - The BMSB is reported in the literature to be a pest in four countries in eastern Asia: Japan, Korea, Taiwan, and China. If we can locate a more precise origin of the population, this will have important value with reference to possible future biological control, analysis of pathways of introduction, and perhaps political implications. Maureen Carter, Department of Entomology, Cornell University, is testing specimens to determine the population(s) of origin of PA population:

"Molecular markers are being used to determine the homogeneity of the population in North America and genetic similarities to possible source populations. Preliminary results from comparison of mitochondrial COI sequence data indicated only one maternal haplotype is found in Allentown, PA and this haplotype is more similar to a specimen from Japan than a specimen from Taiwan. Sequences from additional specimens are being added to the data set" (Carter, pers. comm.).

3. Information Brochure on *Halyomorpha halys*. Attempts to produce an information brochure or fact sheet through USDA channels were not successful. As an alternative, a grant was applied for, co-authored with John Berry, Agricultural Marketing Educator, Penn. State Cooperative Extension, Lehigh County, PA. Karen Bernhard, the part time technician for this project, who also holds a part time position with Lehigh County Extension, was the third author on the proposal. Grant title was Brown Marmorated Stink Bug, General Awareness, and Commercial Producer Awareness; Information Brochure submitted to PA Extension Integrated Pest Management Grant Program. The grant was awarded on December 12, 2003; publication planned for May, 2004.

**Presentations at professional meetings presenting results from the project:**  
(to view abstracts and posters : <http://www.cphst.org> )

- **Bernon, G.**, K.M. Bernhard, E.R. Hoebeke, M.E. Carter, and L. Beanland. 2004. *Halyomorpha halys*, (Heteroptera: Pentatomidae), The Brown Marmorated Stink Bug; are Trees the Primary Host for this New Invasive Pest? Poster presented at: 2004 USDA Interagency Research Forum On Gypsy Moth & Other Invasive Species. January 13–16, Annapolis, MD
- <http://www.cphst.org/docs/Bernon-presentation04.ppt>
- **Bernon, G.**, K.M. Bernhard, E.R. Hoebeke, M.E. Carter. 2003. *Halyomorpha halys*, (Heteroptera: Pentatomidae), New Nuisance Pest; and Future Agricultural Problem? Annual Meeting - The Entomological Society of America. page 94 of program.
- <http://www.cphst.org/docs/ESA2003d.ppt>
- **Bernon, G.L.**, E.R. Hoebeke, M.E. Carter, K.M. Bernhard, and J.F. Stimmel. 2003. Status of the Brown Marmorated Stink Bug, *Halyomorpha halys*, (Heteroptera: Pentatomidae), a New Invasive Species in Pennsylvania. *Poster presented at:* 2003 USDA Interagency Research Forum On Gypsy Moth & Other Invasive Species. January 14–17, Annapolis, MD.
- <http://www.cphst.org/docs/Annapolis03.pdf> , <http://www.cphst.org/docs/Bernon-Annapolis2003.pdf>
- **Bernon, G.**, K.M. Bernhard, J.F. Stimmel, E.R.Hoebeke. 2003. Status of *Halyomorpha halys*, the brown marmorated stink bug, a new invasive insect in Allentown, PA. Eastern Branch, Entomological Society of America 74th Annual Meeting, March 16-18, 2003. (invited symposium speaker)
- <http://www.ento.vt.edu/EBESA/mtnginfo.html>
- **Bernon, G.**, K.M. Bernhard, and J.F. Stimmel. 2004. *Halyomorpha halys*, coming soon to a theater near you. Eastern Branch, Entomological Society of America 75<sup>th</sup> Annual Meeting, March 7-9, 2004. (invited symposium speaker)
- <http://www.ento.vt.edu/EBESA/mtnginfo.html>

## Summary

- *Halyomorpha halys* has not established dense populations in any commercial agroecosystems (as of 2004); but this may happen in the next growing season, and until then, it is unknown what the impact will be.
- The results from one season of monitoring within the infestation confirmed damage to tree fruits, albeit in a small-scale growing operation with a wet growing season; one season was sufficient to establish a base-line, but not to evaluate trends.
- *Halyomorpha halys* is polyphagous, observed on over 60 host plants, including row crops (soybeans), fruit trees (both stone fruits and pomes), ornamentals (butterfly bush), weeds; attacking both fruits and leaves.
- In PA, site of original infestation and this study, *H. halys* is univoltine; however, because of similar behavior to indigenous species and patterns in area of origin, we believe *H. halys* will be multivoltine in more southern latitudes.
- *Halyomorpha halys* appears to have entered a phase of rapid expansion, and will rapidly spread not only from original infestation but also from more isolated populations. The final distribution in North America will be similar to *Acrosternum hilare*, the green stink bug: “ranges from Quebec and New England west through southern Canada and the northern United States to the Pacific Coast and south and southwest to Florida, Texas, Arizona, Utah and California (McPherson 1982).
- The southern green stink bug, *Nezara viridula*, is the best model species for predicting the future potential pest status of *H. halys*; however, *unlike N. viridula*, *H. halys* is cold hardy and can thrive in more northern latitudes.
- *Halyomorpha halys* is an important nuisance pest and this publicity has distracted from the future agricultural importance of this species.

## LITERATURE CITED

- Bernon, G., K.M. Bernhard, E.R. Hoebeke, M.E. Carter. 2003. *Halyomorpha halys*, (Heteroptera: Pentatomidae), New Nuisance Pest; and Future Agricultural Problem? Annual Meeting - The Entomological Society of America. page 94 of program.
- Bernon, G., E.R. Hoebeke, M.E. Carter, K.M. Bernhard, and J.F. Stimmel. 2003. Status of the Brown Marmorated Stink Bug, *Halyomorpha halys*, (Heteroptera: Pentatomidae), a New Invasive Species in Pennsylvania. *Poster presented at: 2003 USDA Interagency Research Forum* . January 14–17, Annapolis, MD.
- Bernon, G., K.M. Bernhard, J.F. Stimmel, E.R.Hoebeke. 2003. Status of *Halyomorpha halys*, the brown marmorated stink bug, a new invasive insect in Allentown, PA. Eastern Branch, Entomological Society of America 74th Annual Meeting, March 16-18, 2003. (invited symposium speaker)
- Bernon, G., K.M. Bernhard, E.R. Hoebeke, M.E. Carter, and L. Beanland. 2004. *Halyomorpha halys*, (Heteroptera: Pentatomidae), The Brown Marmorated Stink Bug; are Trees the Primary Host for this New Invasive Pest? Poster presented at: 2004 USDA Interagency Research Forum. January 13–16, Annapolis, MD
- Bernon, G., K.M. Berhard, and J.F. Stimmel. 2004. *Halyomorpha halys*, coming soon to a theater near you. Eastern Branch, Entomological Society of America 75<sup>th</sup> Annual Meeting, March 7-9, 2004. (invited symposium speaker)
- Dietrick, E. J. and R. van den Bosch. (1957) Insectary propagation of the squash bug and its parasite *Trichopoda pennipes* Fabr. J. Econ. Entomol. 50: 627-629.
- Hoebeke, E.R., and M.E. Carter. 2003. *Halyomorpha halys* (Stal), (Heteroptera: Pentatomidae) a polyphagous plant pest from Asia newly detected in North America. Proc. Entomol. Soc. Wash. 105(1): 225-237.
- Jin, K.X., C.J. Liang, and D.L. Deng. 1981. A study of the insect vectors of witches' broom in Paulownia trees. Linze Keji Tongxun. 12: 23-24.
- Jones, W.A. 1988. World Review of the parasitoids of the southern green stink bug, *Nezara viridula*. Ann. Entomol. Soc. Am. 81(2):262-73
- McPherson, J.E. 1982. The Pentatomoidea (Hemiptera) of nottheastern North America with emphasis on the fauna of Illinois. Southern Illinois Univ. Press, Carbondale and Edwardsville. 240 pp.
- McPherson, J.E., and R.M. McPherson. 2000. Stink bugs of economic importance in America north of Mexico. CRC Press. 253 pages.
- Welliver, R. 1999. Phytoplasma Diseases. Regulatory Horticulture. 25(1): 17-22.